

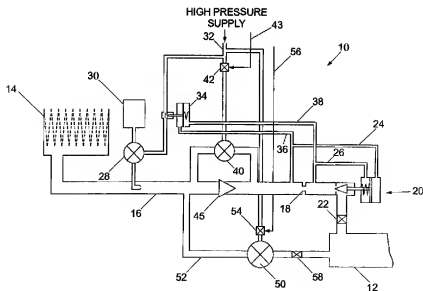
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(54) Title: APPARATUS FOR AND METHOD OF FLOODING AND/OR PRESSURE TESTING PIPELINES



(57) Abstract: Apparatus for and methods of flooding and/or pressure testing a pipe (12) or facility, wherein a subsea device (50) is used to pressure test the pipe (12) once flooded. The subsea device is typically a pump (50) that is located subsea, and preferably supplied from a local power supply (e.g. batteries, ROV, AUV etc). Certain embodiments allow the pipe (12) to be flooded and then pressure tested in consecutive operations without having to de-couple and/or couple additional apparatus to the pipe (12).

1 "Apparatus for and Method of Flooding and/or
2 Pressure Testing Pipelines"

3

4 The present invention provides apparatus and methods
5 for flooding of pipelines or facilities, and more
6 particularly, but not exclusively, to pressure
7 testing (also called hydro or leak testing) of the
8 pipeline or facility once flooded.

9

10 It is conventional to flood subsea pipelines that
11 are normally air- or gas-filled when they are
12 initially laid on the seabed, typically from a lay
13 barge or vessel. As the pipeline is air- or gas-
14 filled, it is generally light and can be affected by
15 storms, tides or currents that can move the
16 pipeline. This can cause damage to the pipeline and
17 the pipeline is generally flooded to make it heavier
18 and thus less susceptible to tides, currents and
19 storms.

20

21 There are a number of ways in which to flood a
22 pipeline, and it is typically done by pumping water

1 (e.g. seawater) into one end of the pipeline in
2 order to drive a pig through it. The conventional
3 method typically uses a surface vessel or surface
4 installation from which extends a large-bore, high-
5 pressure pipe or hose to carry the high-pressure
6 flow of water to the pipeline on the seabed. The
7 surface vessel must also be equipped with a
8 relatively large pump of considerable horsepower,
9 all of which increase the costs involved in this
10 operation, particularly as the vessel must remain *in*
11 *situ* during the flooding of the pipeline.

12
13 Once the pipeline has been flooded, it is desirable
14 to pressure test it to ensure that there are no
15 leaks and that it can withstand high pressures.
16 This generally involves the use of a pump on the
17 surface vessel that supplies water at high pressure
18 to the pipeline to increase the internal pressure
19 therein to a predetermined level. The pressure is
20 then held at this level for a period of time,
21 typically for around 24 hours. The surface vessel
22 typically remains *in situ* during the pressure test
23 to monitor the status of the pipeline, and this can
24 add significant costs to the operation.

25
26 It is to be understood that certain embodiments of
27 the present invention can be used to pressure test a
28 pipeline or facility that has previously been
29 flooded using any conventional method.

30
31 According to a first aspect of the present
32 invention, there is provided apparatus for pressure

1 testing a pipe or facility, the apparatus comprising
2 an inlet having an opening to admit fluid into the
3 pipe or facility, a flow control device to control
4 the flow rate of fluid into the pipe or facility,
5 and a subsea device to supply a pressurised fluid at
6 high pressure into the pipe or facility.

7
8 According to a second aspect of the present
9 invention, there is provided a method of pressure
10 testing a pipe or facility, the method comprising
11 the steps of admitting fluid into the pipe or
12 facility to flood it, introducing a pressurised
13 fluid into the pipe or facility, and monitoring the
14 retention of fluid within the pipe or facility.

15
16 The invention also provides apparatus for pressure
17 testing a subsea pipe or facility, the apparatus
18 comprising a subsea device for introducing a
19 pressurised fluid into the pipe or facility at high
20 pressure.

21
22 The invention further provides a method of pressure
23 testing a subsea pipe or facility, the method
24 comprising the step of actuating a subsea device to
25 introduce a pressurised fluid into the pipe or
26 facility at high pressure.

27
28 In certain embodiments, the method includes the
29 additional step of providing a subsea device. The
30 method typically includes the additional step of
31 coupling the subsea device to the pipe or facility.
32 This can be done at the surface or subsea.

1
2 The pressurised fluid is typically pressurised
3 seawater, but may be a gas (e.g. air) or any other
4 suitable fluid. The fluid is typically water (e.g.
5 seawater).

6
7 The subsea device is typically capable of providing
8 high pressures, typically at low flow rates.

9
10 The subsea device typically comprises a pump. The
11 pump is preferably a high-pressure, low-flow rate
12 pump. The pump is typically electrically operated,
13 and can be coupled to an electrical supply from, for
14 example, a surface vessel or installation. It will
15 be appreciated that it is relatively simple to drop
16 an electrical cable to the seabed when compared with
17 relatively large-bore conduits that are capable of
18 carrying high-pressure fluids.

19
20 Alternatively, the pump could be hydraulically
21 operated, and can be coupled to a hydraulic fluid
22 supply from, for example a surface vessel or
23 installation. Again, it is relatively simple to
24 drop a relatively small-bore hydraulic hose from the
25 surface to the seabed when compared with a
26 relatively large-bore conduit.

27
28 However, the pump is preferably supplied by a local
29 power supply. This provides the advantage that an
30 electrical cable or hydraulic hose is not required
31 to be dropped from a support vessel. The local
32 power supply can be a battery or a bank of

1 batteries. The battery or batteries can be charged
2 using an alternator or the like that is typically
3 coupled into the inlet. The alternator can include
4 a turbine or the like, where the turbine is driven
5 by the flow of fluid through the inlet. Thus, the
6 flow of fluid drives the turbine and thus the
7 alternator to charge the battery or batteries.

8
9 Alternatively, the local power supply may comprise
10 an electrical or other (e.g. hydraulic or pneumatic)
11 power supply from a remotely operated vehicle (ROV)
12 or autonomous vehicle (AUV).

13
14 As a further alternative, the pump can be
15 hydraulically or pneumatically powered using an
16 appropriate power source.

17
18 As a further alternative, the subsea device may
19 comprise one or more gas bottles or any other supply
20 of pressurised fluid, where the bottles are
21 typically capable of providing a high-pressure, low-
22 flow gas into a reservoir or other container of
23 fluids (e.g. seawater). The gas bottle(s) typically
24 admit pressurised gas into the reservoir and force
25 pressurised fluid into the pipe or facility that is
26 being pressure tested. The gas bottles are
27 typically coupled via a regulating device that
28 controls the flow of gas into the reservoir and thus
29 the flow of pressurised fluid into the pipe or
30 facility. The regulating device may comprise a
31 remotely operated valve for example. Thus, the flow
32 of gas into the reservoir causes a flow of fluids

1 into the pipe or facility that can be used to
2 pressure test it.

3

4 The inlet is typically coupled to the pipe via a
5 pipe inlet port, and can be coupled underwater to
6 the inlet port by a diver, ROV or AUV. The inlet
7 can be coupled to the facility using any
8 conventional means.

9

10 The apparatus typically includes a flow-recording
11 device for measuring and/or recording the flow of
12 fluid entering the pipe or facility. The flow-
13 recording device is typically located in the inlet,
14 but may be located at any convenient location. The
15 flow recording device can be a dial that is coupled
16 into the inlet and can be read using an underwater
17 camera on an ROV for example. Alternatively, the
18 flow-recording device may be electrically or
19 otherwise coupled (e.g. via a telemetry system) to
20 the surface for remote monitoring.

21

22 The inlet typically includes an isolating valve that
23 can be opened and closed to admit or restrict fluid
24 flow into the pipe or facility.

25

26 The flow control device typically comprises a
27 variable opening valve that can be remotely or
28 locally operated (e.g. in response to changes in
29 fluid pressure) to maintain a substantially constant
30 flow of fluid into the pipe or facility.

31

1 The inlet preferably contains a filter that can be
2 used to filter or strain the fluid that is admitted
3 into the pipe or facility. Optionally, the
4 apparatus may include a chemical injection device
5 for injecting chemicals into the fluid entering the
6 pipe or facility. The chemical injection device
7 typically comprises a pump that is in fluid
8 communication with one or more reservoirs of
9 chemical additives.

10
11 The step of admitting fluid into the pipe or
12 facility typically involves opening the isolating
13 valve to allow fluid to flow into the pipe or
14 facility under the head of water above the pipe or
15 facility. That is, the hydrostatic head of water
16 above the pipe or facility is typically used to
17 flood it.

18
19 The step of providing fluid into the pipe at high
20 pressure typically involves actuation of the subsea
21 device.

22
23 The apparatus, including the subsea device, is
24 typically provided on a single subsea skid. This
25 provides the advantage that the pipe or facility can
26 be flooded and pressure tested without having to
27 couple and de-couple various equipment and apparatus
28 to and from the pipe or facility. However, it will
29 be appreciated that the subsea device may be located
30 on a separate skid, or can be coupled to an ROV or
31 AUV for example.

32

1 GB2303895B, the entire disclosure of which is
2 incorporated herein by reference, describes a
3 suitable underwater pipeline apparatus for
4 delivering a pig unit through a seabed pipeline that
5 uses the hydrostatic pressure difference between the
6 inside of the pipeline and the surrounding seawater
7 to admit water into the pipeline in a controlled
8 manner, typically through a flow regulator and a
9 filtration system.

10

11 The method preferably includes the additional step
12 of filtering the fluid that enters the pipe or
13 facility.

14

15 The method optionally includes the additional step
16 of adding chemicals to the fluid that enters the
17 pipe or facility.

18

19 The pipe typically comprises a pipeline, and
20 preferably a subsea pipeline.

21

22 Embodiments of the present invention shall now be
23 described, by way of example only, with reference to
24 the accompanying drawing, in which:

25

26 Fig. 1 is a schematic representation of an
27 exemplary embodiment of apparatus for flooding
28 and pressure testing a pipeline;

28

29 Fig. 2 is a schematic representation of an
30 alternative embodiment of apparatus for
flooding and pressure testing a pipeline; and

1 Fig. 3 is a schematic representation of a
2 pipeline laid on the seabed between two subsea
3 installations.

4
5 Referring to the drawings, Fig. 1 shows an
6 embodiment of apparatus 10 for use in flooding and
7 pressure testing (also called hydro or leak testing)
8 a pipeline 12. The pipeline 12 can be of any
9 conventional size and type, and is generally an
10 initially air- or gas-filled pipeline that is laid
11 on the seabed (not shown) in any conventional
12 manner. However, embodiments of the present
13 invention can be used with a pipeline or facility
14 that has previously been flooded using any
15 conventional method. It is also to be noted that
16 embodiments of the present invention will be
17 described with reference to a pipeline, but the
18 invention can be used to flood and/or pressure test
19 other subsea facilities and installations.

20
21 Apparatus 10 typically includes an intake filter 14
22 that is capable of straining the surrounding
23 seawater to remove substantially all of the
24 contaminants before it is allowed to enter the
25 pipeline 12. However, the intake filter 14 need
26 only strain the seawater to the required standard
27 rather than remove substantially all the
28 contaminants. Thus, the intake filter 14 is
29 preferably capable of straining the seawater to the
30 required standard, but is also preferably capable of
31 providing water at a flow rate necessary to flood
32 the pipeline 12.

1
2 The intake filter 14 is coupled to the pipeline 12
3 via a conduit 16 that includes an orifice plate 18,
4 a variable choke, generally designated 20, and an
5 isolating valve 22. The variable choke 20 can be
6 used to adjust the flow of water into the pipeline
7 12 to compensate for the diminishing hydrostatic
8 head that inevitably occurs, for as long as is
9 practicable. The variable choke 20 is automatically
10 controlled in response to the currently existing
11 flow rate by use of differential pressure lines 24,
12 26 that are coupled on each side of the orifice
13 plate 18.

14
15 Alternatively, the variable choke 20 can be
16 automatically controlled using a pressure-operated
17 device such as a diaphragm that is coupled to each
18 side of the orifice plate 18.

19
20 The isolating valve 22 is used to control the
21 flooding of the pipeline 12 and in particular is
22 used to initiate the process of flooding the
23 pipeline 12. The isolating valve 22 can be remotely
24 operated by a control line (not shown) to the
25 surface, or can be actuated by a diver or ROV.

26
27 The apparatus 10 optionally includes an injection
28 pump 28 that is capable of injecting or pumping
29 additive chemicals into the conduit 16 and thus the
30 pipeline 12. The additive chemicals are typically
31 stored in a reservoir 30, although it will be
32 appreciated that a number of reservoirs 30 and/or

1 pumps 28 may be used, depending on the particular
2 chemicals (or other additives) that are to be added
3 to the seawater. The injection pump 28 is driven
4 from a high-pressure supply 32 through an injection
5 control valve 34. The injection control valve 34
6 can control the flow of the injected chemicals
7 according to the prevailing hydrostatic pressure, or
8 at a flow rate that varies with the water flow rate
9 into the pipeline 12 (e.g. to be approximately
10 proportional to the amount of water flowing into the
11 pipeline 12). The latter can be derived from a
12 pressure differential across the orifice plate 18
13 via differential pressure lines 36, 38.
14 Alternatively, the injection pump 28 can be driven
15 from a system of fixed or variable orifices that can
16 control the rate of adding of the chemicals.
17
18 The chemical additives contained in the reservoir 30
19 may be used, for example, to assist in detecting
20 leaks during pressure testing and/or as a corrosion
21 inhibitor.
22
23 It will be appreciated that the hydrostatic pressure
24 difference diminishes as the pipeline 12 floods and
25 the pressure between the interior of the pipeline 12
26 and the surrounding seawater will eventually
27 equalise. At this point, the flooding of the
28 pipeline 12 will cease. It is therefore useful to
29 provide a means by which pressurised water can be
30 admitted to the pipeline 12 to completely flood the
31 pipeline 12 after the hydrostatic head has
32 diminished. In the embodiment shown in Fig. 1, a

1 boost pump 40 is provided that is operable via a
2 remotely operated valve 42. The valve 42 is
3 typically controlled via a control line 43 from the
4 surface, or may be operated by a diver, ROV or AUV,
5 but can be automatically actuated when a reduction
6 in flow rate is detected (e.g. by use of
7 differential pressure lines on each side of the
8 orifice plate 18).

9

10 The boost pump 40 can be powered from the surface or
11 preferably from a local power supply such as from
12 the ROV, AUV or some other power supply (e.g.
13 batteries, hydraulic power source etc). The boost
14 pump 40 is preferably located downstream of the
15 injection pump 28 so that chemicals may be added to
16 the water used to flood the pipeline 12 (e.g. to
17 assist in leak detection).

18

19 The conduit 16 can optionally include a one-way or
20 check valve 45 to prevent the flow of water back
21 towards the intake filter 14.

22

23 The apparatus 10 may include a pig (not shown) that
24 is pumped along the pipeline 12 as it is being
25 flooded. It is desirable to track the location of
26 the pig within the pipeline 12 and this can be done
27 using any conventional means (e.g. a telemetry
28 system). Tracking the position of the pig allows
29 the extent of flooding of the pipeline 12 to be
30 monitored and controlled.

31

1 Additionally, it is advantageous to monitor the flow
2 rate of the water into the pipeline 12 as it is
3 being flooded. Thus, the apparatus 10 may include a
4 flow recording device (not shown) such as a dial
5 that can be read by an underwater camera provided on
6 an ROV. The flow recording device can be of any
7 conventional type, and can be electrically or
8 otherwise coupled (e.g. via a telemetry system) to
9 the surface for remote monitoring of the water flow
10 rate.

11

12 Once the pipeline 12 has been flooded using the
13 apparatus described above, it is then generally
14 pressure tested to ensure that there are no fluid
15 leaks.

16

17 Apparatus 10 includes a low-flow rate but high
18 pressure pump 50 to pressure test the pipeline 12 so
19 that the pressure, hydro or leak testing can follow
20 the flooding of the pipeline 12 without the
21 intervention of a support or surface vessel, or at
22 least with less intervention than is common in the
23 art.

24

25 Pump 50 is coupled to a conduit 52, the inlet of
26 which is preferably coupled downstream of the
27 injection pump 28 so that chemicals can be added to
28 the water if required. The operation of pump 50 is
29 controlled by a remotely operated valve 54 that can
30 be operated via a control line 56 from the surface,
31 or can be actuated by a diver, ROV or AUV. The
32 valve 54 may be automatically operated after the

1 flooding of the pipeline 12 is complete. An
2 isolating valve 58 is located in the conduit 52
3 upstream of the pipeline 12 so that the conduit 52
4 can be opened and closed as required (e.g. to assist
5 in leak detection). Operation of the isolating
6 valve 58 may be automatic (e.g. actuated when the
7 pump 50 is actuated) or may be remotely operated
8 from the surface, or by a diver, ROV or AUV.

9

10 The pump 50 is actuated to provide a high-pressure
11 flow of water, typically at a relatively low flow
12 rate, into the pipeline 12. The high-pressure, low
13 flow of water increases the pressure within the
14 pipeline 12 so that any leaks or weak points in the
15 pipeline 12 can be detected. Chemicals may be added
16 to the water to facilitate identifying the source of
17 any leaks.

18

19 Only a relatively low flow rate of water is required
20 as the pipeline 12 is already filled with water and
21 only the internal pressure within the pipeline 12
22 need be increased. The volume of water that enters
23 the pipeline 12 during pressure testing can be
24 considerably less than that required to flood it.

25

26 Referring now to Fig. 3 there is shown as an example
27 a 12-inch (approximately 300 millimetre) bore
28 pipeline 200 that is 5 kilometres long and has been
29 laid on the seabed 202 between two installations
30 204, 206 in a deep-water field. Apparatus 10 is
31 coupled to the pipeline 200 using a conduit 208 that
32 is coupled to a pipeline inlet port, for example,

1 provided at one end of the pipeline 200. Apparatus
2 10 is typically used to flood the pipeline 200 and
3 can then be used to pressure test it in consecutive
4 operations.

5
6 The flooding of the pipeline 200 typically requires
7 a volume of water to fill the pipeline 200 (e.g.
8 using the above described apparatus 10) that is in
9 the order of 360 cubic metres. The additional
10 volume of water required to raise the internal
11 pressure of the pipeline 200 to around 700 bar
12 (10150 psi) is 14% cubic metres. This is only a
13 small percentage (in the order of 4%) of the volume
14 of water required to fill the pipeline 200 in the
15 first instance, and highlights the difference in
16 required capacity between a relatively low-pressure,
17 high flow-rate flooding pump (e.g. boost pump 40)
18 and a high-pressure, low-flow pressure testing pump
19 (e.g. pump 50).

20
21 The pump 50 used for the pressure test typically
22 requires to pressurise the pipeline 200 at
23 approximately 1 bar per minute, and thus the
24 required flow rate from pump 50 would be in the
25 order of 21 litres per minute. If the pipeline 12
26 is to be pressured at around 3 bars per minute, then
27 the corresponding flow rate is around 62 litres per
28 minute.

29
30 Thus, the power required to provide these flow rates
31 at the required pressures would reach a maximum as
32 the final pressure is approached, and this maximum

1 would be around 23 kilowatts (31 horse power) for
2 the 1 bar per minute flow rate, and 60 kilowatts (94
3 horse power) for the 62 litres per minute flow rate.

4
5 Thus, the total energy required to pressurise the
6 pipeline 200 during the pressure test is typically
7 around 500 MJ. This energy can be provided by
8 dropping an electrical cable from a supply or
9 support vessel and coupling this to the pump 50. It
10 will be appreciated that the pump 50 does not need
11 to be actuated during the pressure test; it is only
12 required to raise the internal pressure within the
13 pipeline 12 to the required level. Thereafter, the
14 isolating valves 22, 58 can be closed to retain the
15 pressure within the pipeline 12 during the test.

16
17 Additionally, the vessel can leave the pump 50 *in*
18 *situ* on the seabed during the pressure test (e.g.
19 for a period of around 24 hours). However, a data
20 logger would generally be required in the pipeline
21 12 so that data from the pressure test can be
22 recorded and then up-loaded to the vessel upon its
23 return. The vessel may return periodically to check
24 the data.

25
26 It is preferred that the energy required to drive
27 the pump 50 is provided locally (i.e. subsea) as
28 this has the advantage that the surface vessel is
29 not required to provide power for operating the pump
30 50. Thus, embodiments of the present invention
31 provide the advantage that a smaller and cheaper
32 vessel can be used that is provided with a suitable

1 power supply for the pump (e.g. electric or
2 hydraulic); the vessel does not require a pump and
3 associated equipment on board.

4
5 The energy for pump 50 can be provided by a remotely
6 operated vehicle (ROV) 210 that is coupled to
7 apparatus 10 using an electrical cable 212. The ROV
8 can be used to couple and de-couple the cable 212 as
9 is known in the art.

10
11 Alternatively, the energy can be provided by a local
12 (subsea) power supply such as a bank of suitable
13 batteries. The batteries can be charged during
14 flooding of the pipeline 200 by coupling an
15 alternator or the like into the conduit 16 at an
16 appropriate place so that the flow rate through the
17 conduit 16 drives a turbine in the alternator that
18 generates a sufficient current to charge the
19 batteries.

20
21 It is preferred that the power to the pump 50 is
22 provided locally so that there is no surface
23 connection, although this may be possible in
24 relatively shallow water or where there is access to
25 a surface vessel. There is also the potential to
26 use a smaller boat with less personnel and equipment
27 as the pump used for pressure testing and the
28 associated equipment would not be required on board
29 the vessel; all that is required is an electrical
30 cable or a hydraulic hose to be dropped to the
31 seabed 202 for coupling to the apparatus 10 (e.g. by
32 ROV 210).

1
2 As an alternative to using power from batteries or
3 from an electrical cable from a surface vessel, the
4 power for the pump 50 may also be provided by the
5 ROV 210 or an autonomous vehicle (AUV - not shown).
6 This would require the pump 50 to be provided with a
7 suitable connector that can be engaged and
8 disengaged by the ROV 210 or AUV so that power can
9 be provided. Thus, the ROV 210 or AUV would be
10 coupled to the pump 50 in any conventional manner to
11 provide power thereto, and then de-coupled once the
12 pressure test is complete. Indeed, the pump 50 may
13 form a part of the ROV or AUV itself, and thus can
14 be provided with electrical or hydraulic power
15 therefrom.

16
17 Alternatively, the pump 50 may be pneumatically or
18 hydraulically powered. For example, a hydraulic
19 hose may be dropped from the surface vessel to
20 provide hydraulic power to the pump 50.
21 Alternatively, a suitable coupling can be used
22 between the ROV or AUV to provide hydraulic or
23 pneumatic power to the pump 50.

24
25 It will be appreciated that the above apparatus 10
26 has been described where the pump 50 forms a part of
27 the apparatus 10, but it will also be appreciated
28 that the pump 50 may be provided on a separate
29 subsea skid to the remainder of the apparatus 10.
30 Having the pump 50 included in a single subsea skid
31 with the remainder of the apparatus 10 provides the
32 advantage that only a single piece of equipment need

1 be lowered to and retrieved from the seabed.
2 Additionally, the apparatus 10 need only be coupled
3 to the pipeline once in order to flood it and
4 pressure test it. There is no requirement to couple
5 and de-couple other equipment to the pipeline using
6 an ROV for example. Both of these are significant
7 advantages when the time taken to raise and lower
8 the apparatus 10 is considered, and also the time
9 taken to couple and de-couple conventional large-
10 bore conduits.

11
12 Indeed, the pump 50 can be used independently of the
13 remainder of the apparatus 10 that is generally used
14 to flood the pipeline 12. The pump 50 can be
15 provided on a separate subsea skid and coupled and
16 de-coupled to the pipeline 12 using a diver, ROV or
17 AUV as necessary. Additionally, the pump 50 may
18 form a part of the ROV or AUV. Thus, the pump 50
19 does not have to be used with the remainder of the
20 apparatus 10 described above, and could be used with
21 other conventional methods of flooding the pipeline
22 12. However, it will be noted that combining the
23 pump 50 with the remainder of the apparatus 10 has
24 significant advantages in that the flooding and
25 pressure testing of the pipeline 12 can be done in
26 consecutive operations, without the intervention of
27 a vessel, and without having to de-couple and couple
28 other equipment and apparatus.

29
30 Referring now to Fig. 2, there is shown an
31 alternative embodiment of apparatus 100 for flooding
32 and pressure testing a pipeline 112. Apparatus 100

1 is similar to apparatus 10, and like numerals
2 prefixed "1" have been used to designate like parts.

3
4 In the embodiment shown in Fig. 2, the pump 50 has
5 been replaced by a gas accumulator bottle or a bank
6 of such, generally designated 160, that is capable
7 of providing high-pressure, low-flow gas into a
8 reservoir 162 or other container of seawater. As
9 the flow of gas from the accumulator bottles 160
10 (typically via a manifold (not shown) so that the
11 gas flow rate can be controlled) enters the
12 reservoir 162, the water therein is forced into the
13 pipeline 112, preferably at high pressure and a low
14 flow rate. The water already in the pipeline 112 is
15 compressed, thus increasing the internal pressure to
16 perform the pressure tests. This particular
17 embodiment is advantageous as an electrical power
18 supply is not required.

19
20 The gas bottles 160 can be filled with gas (e.g. air
21 or the like) at the surface before the apparatus 100
22 is lowered to the seabed. A conduit 164 is coupled
23 to the pipeline 112 so that the pressurised gas from
24 the bottles 160 can enter the reservoir 162 and
25 force pressurised water out of it and into the
26 pipeline 112. A remotely-operated isolating valve
27 166 is coupled into the conduit 162 so that the flow
28 of water into the pipeline 112 can be controlled
29 from the surface (e.g. using a control line 168), or
30 otherwise controlled (e.g. automatically in response
31 to the pressure within the pipeline 112).

32

1 The gas bottles 160 may include a regulating device
2 (not shown) to control the rate at which gas enters
3 the reservoir 162 and also to control the pressure
4 of the water from the reservoir 162 as it enters the
5 pipeline 112. The regulating device can be of any
6 conventional type, and could be a further remotely
7 operated valve that can be controlled from the
8 surface or by a diver, ROV or AUV, or automatically.

9

10 As with the previous embodiment, the gas accumulator
11 bottles 160 may be provided on the same subsea skid
12 as the remainder of the apparatus 100.

13 Alternatively, the bottles 160 may be provided on a
14 separate skid, or can form a part of the ROV or AUV.

15

16 Embodiments of the present invention provide
17 numerous advantages over conventional apparatus for
18 pressure testing pipelines. In particular, there is
19 typically no requirement to use a support vessel at
20 the surface with certain embodiments, thus saving
21 significant costs in terms of manpower and the
22 operation of the vessel, although this remains an
23 option. In the event that power is required from a
24 surface vessel, there is the potential to provide a
25 smaller vessel at the surface with less personnel
26 and less equipment on board the vessel, and this
27 also has the potential to save on costs.

28 Furthermore, the apparatus can be used to flood the
29 pipeline and then to pressure test it in consecutive
30 operations; there is no requirement to couple and
31 de-couple various pumps and other apparatus and

1 equipment to the pipeline in order to flood it and
2 then pressure test it.

3

4 Certain embodiments of the present invention provide
5 a subsea device that can be coupled to a previously
6 flooded pipeline or facility to pressure test it.

7

8 Modifications and improvements may be made to the
9 foregoing without departing from the scope of the
10 present invention. For example, the apparatus and
11 methods have been described in relation to subsea
12 pipelines and installations, but they could be in
13 any underwater environment, such as on a riverbed or
14 lakebed.

15

1 CLAIMS

2

3 1. Apparatus for pressure testing a pipe or
4 facility, the apparatus comprising an inlet having
5 an opening (16, 116) to admit fluid into the pipe
6 (12, 112) or facility (204, 206), a flow control
7 device (20, 120) to control the flow rate of fluid
8 into the pipe (12, 112) or facility (204, 206), and
9 a subsea device (50, 160) to supply a pressurised
10 fluid at high pressure into the pipe (12, 112) or
11 facility (204, 206).

12

13 2. Apparatus according to claim 1, wherein the
14 subsea device (50, 160) is capable of providing high
15 pressures at low flow rates.

16

17 3. Apparatus according to either preceding claim,
18 wherein the subsea device comprises a pump (50).

19

20 4. Apparatus according to claim 3, wherein the
21 pump (50) is electrically operated.

22

23 5. Apparatus according to claim 3, wherein the
24 pump (50) is hydraulically operated.

25

26 6. Apparatus according to any one of claims 3 to
27 5, wherein the pump (50) is supplied by a local
28 power supply.

29

30 7. Apparatus according to claim 6, wherein the
31 local power supply comprises one or more batteries.

32

1 8. Apparatus according to claim 7, wherein the or
2 each battery is charged using an alternator coupled
3 into the inlet (16, 116).
4

5 9. Apparatus according to claim 6, wherein the
6 local power supply comprises an electrical,
7 hydraulic or pneumatic power supply from a remotely
8 operated vehicle (210) or autonomous vehicle.
9

10 10. Apparatus according to claim 1 or claim 2,
11 wherein the subsea device comprises one or more gas
12 bottles (160).
13

14 11. Apparatus according to claim 10, wherein the or
15 each bottle (160) is capable of providing a high-
16 pressure, low-flow gas into a reservoir (162) or
17 other container of fluids.
18

19 12. Apparatus according to claim 11, wherein the or
20 each gas bottle (160) admits pressurised gas into
21 the reservoir (162) and forces pressurised fluid
22 into the pipe (12, 112) or facility (204, 206) that
23 is being pressure tested.
24

25 13. Apparatus according to any preceding claim,
26 wherein the inlet (16, 116) is coupled to the pipe
27 (12, 112) via a pipe inlet port.
28

29 14. Apparatus according to any preceding claim,
30 wherein the apparatus includes a flow-recording
31 device for measuring and/or recording the flow of

1 fluid entering the pipe (12, 112) or facility (204,
2 206).

3

4 15. Apparatus according to any preceding claim,
5 wherein the flow control device comprises a variable
6 opening valve (20, 120) that can maintain a
7 substantially constant flow of fluid into the pipe
8 (12, 112) or facility (204, 206).

9

10 16. Apparatus according to any preceding claim,
11 wherein the inlet (16, 116) contains a filter (14,
12 114) that can be used to filter or strain the fluid
13 that is admitted into the pipe (12, 112) or facility
14 (204, 206).

15

16 17. Apparatus according to any preceding claim,
17 wherein the apparatus includes a chemical injection
18 device (28, 128) for injecting chemicals into the
19 fluid entering the pipe (12, 112) or facility (204,
20 206).

21

22 18. Apparatus for pressure testing a subsea pipe or
23 facility, the apparatus comprising a subsea device
24 (50, 160) for introducing a pressurised fluid into
25 the pipe (12, 112) or facility (204, 206) at high
26 pressure.

27

28 19. Apparatus according to claim 18, wherein the
29 subsea device (50, 160) is capable of providing high
30 pressures at low flow rates.

31

- 1 20. Apparatus according to claim 18 or claim 19,
2 wherein the subsea device comprises a pump (50).
3
- 4 21. Apparatus according to claim 20, wherein the
5 pump (50) is supplied by a local power supply.
6
- 7 22. Apparatus according to claim 21, wherein the
8 local power supply comprises one or more batteries.
9
- 10 23. Apparatus according to claim 22, wherein the or
11 each battery is charged using an alternator.
12
- 13 24. Apparatus according to claim 21, wherein the
14 local power supply comprises an electrical,
15 hydraulic or pneumatic power supply from a remotely
16 operated vehicle (210) or autonomous vehicle.
17
- 18 25. Apparatus according to claim 18 or claim 19,
19 wherein the subsea device comprises one or more gas
20 bottles (160).
21
- 22 26. Apparatus according to claim 25, wherein the or
23 each bottle (160) is capable of providing a high-
24 pressure, low-flow gas into a reservoir (162) or
25 other container of fluids.
26
- 27 27. Apparatus according to claim 26, wherein the or
28 each gas bottle (160) admits pressurised gas into
29 the reservoir (162) and forces pressurised fluid
30 into the pipe (12, 112) or facility (204, 206) that
31 is being pressure tested.
32

- 1 28. A method of pressure testing a pipe or
2 facility, the method comprising the steps of
3 admitting fluid into the pipe (12, 112) or facility
4 to flood it, introducing a pressurised fluid into
5 the pipe (12, 112) or facility (204, 206), and
6 monitoring the retention of fluid within the pipe
7 (12, 112) or facility (204, 206).
8
- 9 29. A method according to claim 28, wherein the
10 method includes the additional step of providing a
11 subsea device (50, 160) to introduce the pressurised
12 fluid).
13
- 14 30. A method according to claim 29, wherein the
15 method includes the additional step of coupling the
16 subsea device (50, 160) to the pipe (12, 112) or
17 facility (204, 206).
18
- 19 31. A method according to any one of claims 29 to
20 30, the step of admitting fluid into the pipe (12,
21 112) or facility (204, 206) involves opening an
22 isolating valve (58, 166) to allow fluid to flow
23 into the pipe (12, 112) or facility (204, 206) under
24 the head of water above the pipe (12, 112) or
25 facility (204, 206).
26
- 27 32. A method according to any one of claims 29 to
28 31, wherein the step of introducing a pressurised
29 fluid into the pipe (12, 112) or facility (204, 206)
30 involves the step of actuating the subsea device
31 (50, 160).
32

1 33. A method according to any one of claims 28 to
2 32, wherein the method includes the additional step
3 of filtering the fluid that enters the pipe (12,
4 112) or facility (204, 206).

5

6 34. A method according to any one of claims 28 to
7 33, wherein the method includes the additional step
8 of adding chemicals to the fluid that enters the
9 pipe (12, 112) or facility (204, 206).

10

11 35. A method of pressure testing a subsea pipe or
12 facility, the method comprising the step of
13 actuating a subsea device (50, 160) to introduce a
14 pressurised fluid into the pipe (12, 112) or
15 facility (204, 206) at high pressure.

16

17 36. A method according to claim 35, wherein the
18 method includes the additional step of coupling the
19 subsea device (50, 160) to the pipe (12, 112) or
20 facility (204, 206).

21

22 37. A method according to claim 35 or claim 36,
23 wherein the step of actuating the subsea device (50,
24 160) comprises providing power to the device (50,
25 160).

26

27 38. A method according to claim 37, wherein the
28 power can be electrical, hydraulic or pneumatic.

29

30 39. A method according to claim 37 or claim 38,
31 wherein the method includes the additional step of

1 coupling a remotely operated vehicle (210) or
2 autonomous vehicle to the subsea device (50, 160).
3

4 40. A method according to any one of claims 35 to
5 39, wherein the method includes the additional step
6 of filtering the fluid that enters the pipe (12,
7 112) or facility (204, 206).
8

9 41. A method according to any one of claims 35 to
10 40, wherein the method includes the additional step
11 of adding chemicals to the fluid that enters the
12 pipe (12, 112) or facility (204, 206).
13
14

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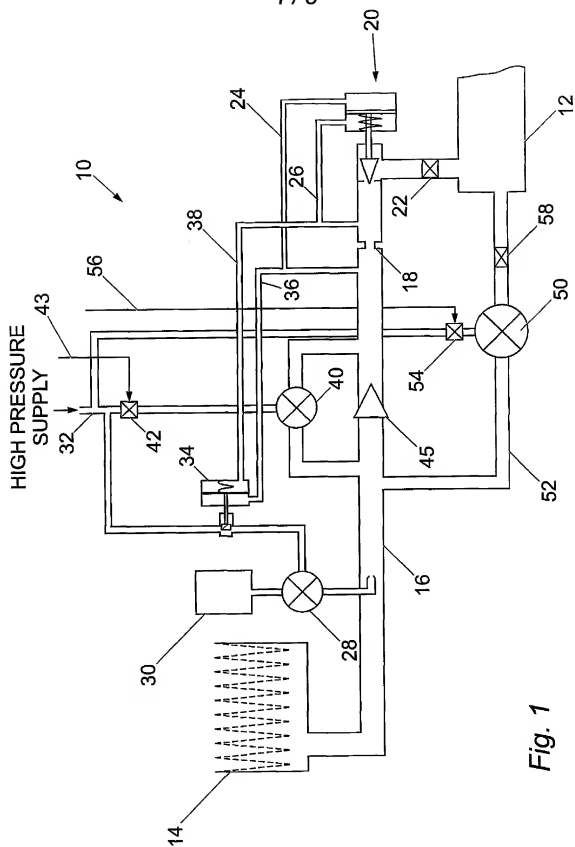


Fig. 1

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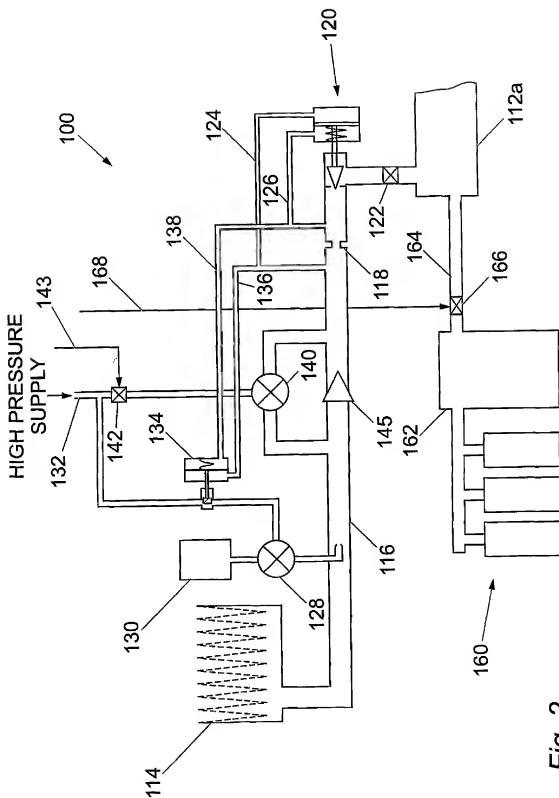


Fig. 2

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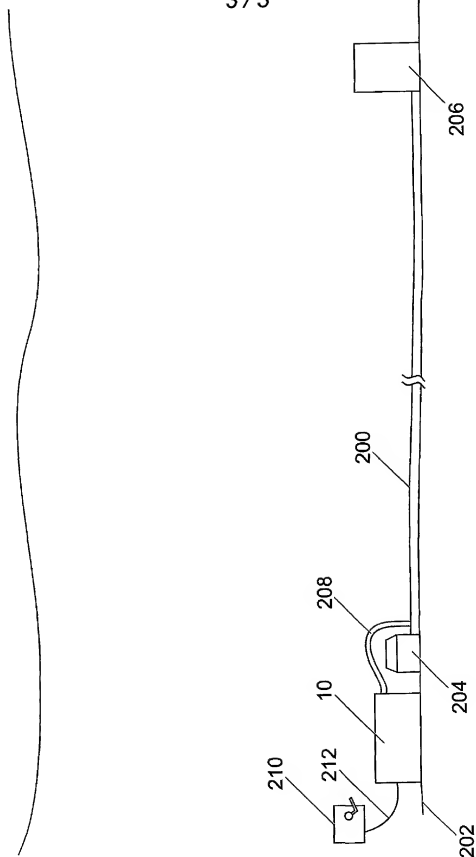


Fig. 3

WO 2002/088658 A3

INTERNATIONAL SEARCH REPORT

PCT/GB 02/01997

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01M3/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 G01M F16L G01F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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☒ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

13 October 2003

Date of mailing of the international search report

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| C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT | | |
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WO02088658A2 Family Legal Status Report - 7 members found

Codes shown: All | [Positive](#) | [Negative](#)

| Jump | Publication | Title | Filed | AppNo |
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| Status | WO02088658A2 | APPARATUS FOR AND METHOD OF FLOODING AND/OR PRESSURE TESTING PIPELINES | 2002-05-01 | WO2002GB0001997 |
| Status | GB2390435B2 | Apparatus for and method of flooding and/or pressure testing pipelines | 2002-05-01 | GB2003000025447 |
| Status | GB2390435A1 | Apparatus for and method of flooding and/or pressure testing pipelines | 2002-05-01 | GB2002200325447 |
| Status | GB0325447A0 | Apparatus for and method of flooding and/or pressure testing pipelines | 2002-05-01 | GB2002200325447 |
| Status | GB0110732A0 | | | |
| Status | BR0209306A | Aparelho e método para testar em pressão um tubo ou instalação | 2002-05-01 | BR2002000009306 |

WO02088658A3:

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|---------------------|-------------|---|---------------------------------------|
| 2006-04-17 | NENP | Non-entry into the national phase in: (JP) | |
| 2004-07-07 | 122 - | EP: pct app. not ent. europ. phase | |
| 2004-03-11 | REG | Reference to national code | |
| | DE 8642 - | Impact abolished for de - i.e. pct appl. not ent. german phase | |
| 2003-01-30 | DFPE | Request for preliminary examination filed prior to expiration of 19th month from priority date (pct application filed before 20040101) | |
| 2003-01-02 | 121 | EP: the epo has been informed by wipo that ep was designated in this application | |
| 2002-11-07 | AK + | Designated states cited in a published application without search report (AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW) | |
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WO02088658A2:

| <u>Gazette date</u> | <u>Code</u> | <u>Description (remarks)</u> | <u>List all possible codes for WO</u> |
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| 2006-04-17 | NENP | Non-entry into the national phase in: (JP) | |
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| 2002-11-07 | AL + | Designated countries for regional patents cited in a published application without search report (GH GM KE LS MW MZ SD SL SZ TZ UG ZM ZW AM AZ BY KG KZ MD RU TJ TM AT BE CH CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE TR BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG) | |

GB2390435B2:

| <u>Gazette date</u> | <u>Code</u> | <u>Description (remarks)</u> | <u>List all possible codes for GB</u> |
|---------------------|-------------|--|---------------------------------------|
| 2006-05-24 | 732E | Proceeding under section 32 patents act 1977 | |

GB2390435A1:

| <u>Gazette date</u> | <u>Code</u> | <u>Description (remarks)</u> | <u>List all possible codes for GB</u> |
|---------------------|-------------|--|---------------------------------------|
| 2006-05-24 | 732E | Proceeding under section 32 patents act 1977 | |

GB0110732A0:

| <u>Gazette date</u> | <u>Code</u> | <u>Description (remarks)</u> | <u>List all possible codes for GB</u> |
|---------------------|-------------|--|---------------------------------------|
| 2002-08-21 | AT - | Applications terminated before publication under section 16(1) | |

BR0209306A:

| <u>Gazette date</u> | <u>Code</u> | <u>Description (remarks)</u> | <u>List all possible codes for BR</u> |
|---------------------|-------------|---|---------------------------------------|
| 2006-02-07 | B25A | Entry of change of name and/or headquarter and transfer of application, patent and certificate of addition of invention: transfer granted (TRANSFERIDO DE: PROGENITIVE SERVICES LIMITED) (TRANSFERIDO DE: PROGENITIVE SERVICES LIMITED)(New owner: PSL ENERGY SERVICES LIMITED (GB)) | |